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Prevention of Salt-Spray Injury to Fruit and Ornamental Trees

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Prevention of Salt-Spray Injury to Fruit and Ornamental Trees

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Abstract:	Prevention of salt-spray injury to roadside trees was evaluated during 3 years using chemical protectants. In year one, eighteen different protectants were tested on two apple cultivars, Empire and Golden delicious. During year two, eight protectants were tested on apple, peach, willow, silver ample, lilac, elm, white pine, red pine, and Austrian pine. During the first two years, roadside conditions were simulated with applications of a 2% salt solution. During year three, sites were located by three highways and exposure to salt depended on deicing salt used on those highways. Evaluation was based on Na^+ and CL^- concentrations and injury ratings. Results indicate that five protectants, one agricultural antidesiccant, two industrial chemicals and two research products were effective in preventing salt-spray injury in all the pines tested. Results with the six deciduous species were more variable but encouraging.
Key words:	salt-spray, antidesiccants, fruit trees, salt injury, protectants, ornamental trees, sodium, chlorides, scanning electron microscope, anti-transpirants
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Ontario Ministry of Agriculture and Food
Horticultural Research Institute of Ontario

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EXECUTIVE SUMMARY

Prevention of salt-spray injury to roadside trees was evaluated using various film-forming chemical protectants over a three-year period. During year 1 (1984-1985 winter), 18 protectants were tested on two apple cultivars (Golden Delicious and Empire) and on white pine. These were used as test species because of their known susceptibility to salt-spray injury. Evaluation was based on Cl^- and Na^+ concentrations and also on injury rating (IR) of twigs.

Initial screening of these protectants indicated that eight were promising when applied on apple and six on white pine. During year 2 (1985-1986 winter), these protectants were re-evaluated on Golden Delicious apple at two locations: a site exposed to highway salt along the Q.E.W.; and a site where a 2% salt solution was artificially applied, located at the Horticultural Research Institute of Ontario (HRIO). At HRIO, Empire apple, apple rootstock Malling-26 and white pine also were sprayed.

Five protectants were found to be consistently superior to the control at the Q.E.W. site under moderate salt levels. These were:

- Folicote - agricultural antidesiccant
- Siliconate 51T - industrial wax
- Joncryl 1938 - industrial wax
- RD #1725 - research wax by International Waxes
- RD #1726 - research wax by International Waxes

However, at the HRIO plots where salt levels were high as a result of artificial application, the influence of these protectants was variable.

During year 3 (1986-1987 winter), the above five chemicals were tested further on the following species (locations in brackets): white elm, Austrian pine and lilac (Highway 400); red pine, white pine, black willow and silver maple (Highway 401); apple and peach (Q.E.W.). Results indicated the following:

- All protectants prevented or reduced salt-spray injury in the three pine species.
- There was some prevention of injury on apple trees.
- With the other deciduous species the results were variable and there were no significant differences between the protectants and control.

Scanning electron microscopy was used to determine the integrity of the films at intervals during the winter. This study was limited to apple trees at the Q.E.W. site. Results revealed that the films:

- Covered the twigs of apple evenly.
- Did not crack until February or March, when the cracks were characterized by longitudinal fissures.
- Crystal-like particles were found in the cracks, but few were sodium chloride.

This study provides important insight into the ability of various chemicals to prevent salt-spray injury to roadside plantings. These results are very encouraging but further evaluations over several winters would be desirable.

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1/ GENERAL INTRODUCTION

Deicing salts damage roadside vegetation (Westing 1969, Holmes 1961) either by increasing soil salinity or by salt-spray deposition on woody tissues (Smith 1970). In Ontario, roadside injury to white pine was caused by salt-spray and not by soil-borne salts (Hofstra and Hall 1971). Hofstra and Lumis (1975) observed symptoms typical of salt-spray injury on apple trees along the road and also on apple trees sprayed with deicing salt. It is well established that salt-spray results in extensive damage to both deciduous and evergreen plants growing along highways (Hofstra and Hall 1970, Lumis et al., 1973 and Sucoff 1975, Dirr 1976, Barrick et al. 1979 and Simini and Leone 1982). Injury symptoms differ for deciduous and evergreen plants Hofstra et al. (1979), Dirr (1976) and Sucoff (1975) have summarized these as follows:

EVERGREEN SYMPTOMS

- browning of needles from tip to base, with a sharp boundary between brown and green tissue
- tufted new growth after repeated injury, i.e."Witches-broom" effect
- total browning, often on one side of tree
- premature needle drop of previous year's growth
- reduction of new growth
- reduction of height and diameter of tree
- browning of older needles more extensive than of younger needles

DECIDUOUS SYMPTOMS

- death of flower buds
- death of vegetative buds (1 year or younger)
- twig dieback
- "Witches-broom" effect, often one sided
- premature leaf drop
- reduction of new growth

° leaf burning or "scorch"
° leafing in the spring is delayed

Injury on evergreens becomes apparent in late March/early April when plants become active. Symptom expressions increase with increasing temperature (Hall et al. 1972) and is proportional to the concentration of salt in the needles (Hofstra and Hall 1971). Injury on deciduous trees is apparent in the spring at time of leafing out; dead buds and twigs become obvious and leafing may be delayed.

Some species tolerate high soil-salt and spray-salt, while others are very susceptible to small concentrations. Weicherding (1978), Sucoff (1975), Lumis et al. (1973) and Shortle and Rich (1972) include extensive lists of plants and their tolerance rating to salt-spray. Small discrepancies between listing is due to variation in exogenous (i.e., weather) factors which influence the intensity of damage.

Damage intensity caused by salt-spray can be affected by several factors (Hofstra et al. (1979), Weicherding (1978), Sucoff (1975), Dirr (1976), Lumis et al. (1973)):

° Temperature - damage increases with an increase in temperature; NaCl also lowers the cold hardiness of plants causing winter injury.
° Drought - injury is more severe following a growing season under drought conditions.
° Exposure to wind - injury is more severe downwind, in intersections or other exposed areas.
° Topography - injury is most severe downslope from the road.
° Location of plant - injury is most severe in plants which are close to the road.
° Snow - branches or areas covered with snow are protected from injury.

- Humidity - the availability of water when temperatures increase in the spring results in greater injury.
- Location of branch - injury is most severe on the side which faces the road.
- Spray drift zone - areas beyond this zone may not be affected.
- Average daily traffic (ADT) - injury increases proportionally to an increase in ADT.
- Salt - injury increases with an increase in the quantity of salt applied.
- Age of the plant - young plants are often more susceptible than older ones.

Some of the factors that affect the **sensitivity** of different species to salt-spray are:

- surface to volume ratio; injury is less severe in those species with thick twigs, needles and buds (i.e., high surface to volume ratio).
- surface protectants; those plants with greater amount of wax or resin in the cuticle are more tolerant to salt-spray injury.
- nature of buds and bark; naked buds and thin bark are more susceptible to salt-spray injury.
- physiological tolerance of species.

Strategies to prevent salt-spray injury along roadsides include selection and use of plants tolerant to high sodium and chloride levels and use of physical barriers, such as covering individual or groups of plants (Hvass 1985, Rideout 1978). Wind-controlled irrigation has been used in Israel for wind-borne salt damage to vegetation (Ben-Jaacov et al. 1980). Antitranspirants or antidesiccants have been used with limited success to protect plants from salt-spray (Emmons et al. 1976, Hagan and Davenport 1973, Smith 1971). These chemicals reduce water loss from the plant (Davenport and Hagan 1975) and are of three types: film-forming,

metabolic, and/or reflecting. The film-forming type produces a film which acts as a physical barrier retarding loss of water vapour from plants (Gale 1961). The metabolic type affects physiological processes in the plant by regulating stomata aperture or growth rate (Gale and Hagan 1966, Gale 1961). Reflective materials lower leaf temperature and reduce the vapour pressure gradient from leaf to atmosphere (Abov-kaled et al. 1970, cited in Davenport and Hagan 1975).

Film-forming protectants (antitranspirants) have also been used experimentally to prevent winter injury (Pair and Still 1982, Smith 1971, Fucik 1970, Smith et al. 1966 and White and Weiser 1965), and as a prophylactic treatment against fungal infections (Ziv and Hagiladi 1984, Oded Ziv and Frederiksen 1983 and Gale and Poljakoff-Mayber 1962). These film-forming materials are silicones, waxes, vinyl latex, pine oils, or polymer emulsions.

The objectives of this project were:

- To determine the efficacy of selected chemical protectants with similar film-forming characteristics in preventing salt-spray injury on apple and white pine trees under controlled experiments.
- To determine if any of the protectants were phytotoxic to the test species.
- To evaluate the most promising protectants under highway conditions.
- To select the most promising protectants for further studies.

During the winter of 1984-85, the first year of study, 18 chemicals were applied to two apple cultivars and 15 to white pine. Some of the chemicals used were commercially available protectants, some were industrial chemicals, and others were formulated specifically for this project (Appendix 1). These chemicals included silicone, various

wax emulsions, pine oil emulsion, organic and acrylic polymer emulsions, tall oil emulsion and polyvinyl acetate, polyvinyl alcohol and hydrocarbon resins. During the subsequent winter, eight protectants were applied on apple and six on white pine (Appendix 1). During the 1986-1987 winter, the five best protectants were applied on apple, peach, white pine, red pine, Austrian pine, willow, elm, silver maple and lilac (Appendix 1).

2/ CONTROLLED EXPERIMENTS

2.1/ Materials and Methods

2.1.1/ Apple

2.1.1.1/ Experimental Plot - Thirteen seven-year-old Empire apple trees and 20 Golden Delicious trees located at the Horticultural Research Institute of Ontario, Vineland Station, were used in 1984. In 1985, 13 and 19 seven-year-old Empire and Golden Delicious (field) trees, respectively, from the same block, were used for experiments.

The completely random design (CRD) was used in 1984 and the number of protectants applied on a tree depended on the branches available. In 1985, the randomized complete block design (RCBD) was used with the blocks consisting of one or two trees of Golden Delicious (field). In 1984, each treatment (i.e. 18 protectants and control) was replicated five times while in 1985, eight replicates of each treatment were used (i.e. 8 protectants and control). The treatments were applied at two levels: one and two applications of protectant. During the winter of 1984-1985, 18 protectants (Appendix 1) and a water control were tested and eight were tested during the winter of 1985-1986 (Appendix 1). Protectants were applied at the manufacturers recommended rates, i.e., usually between 7 and 12% solids in solution with two exceptions at 22 and 24% solids (Appendix 2). All protectants were applied with Superspreader® Surfactant (Niagara Chemicals) included at 2.5 ml/litre.

Each protectant was applied to two 30 cm or longer twigs, on the same tree, with a 650 ml trigger-pump sprayer. One twig was used for measuring Na^+ and Cl^- ion levels and the second to determine injury ratings (IR). All twigs were selected from the previous season's growth. Twigs were 0.3 to 0.6 mm

in diameter during 1985-1986 experiments. Protectants were applied only when ambient air temperature exceeded 4°C. Overspray onto adjacent twigs was minimized using a 50 x 80 cm polyethylene sheet.

In 1984, most protectants were applied between 25 and 27 November. One-half of the twigs received a second application of protectants on 29 November. Three protectants not available in November (i.e. #2, 4 and 8, Appendix 1) were applied to different twigs on 17 December, and a second application was made on one-half of those twigs on 18 December. In 1985, protectants 1 to 8 (Appendix 1) were applied between 19 November and 1 December. The second application of protectants was made between 1 and 5 December. Eighteen applications, two per week, of a 2% (wt./vol.) solution of rock salt were applied from 7 January to 7 March 1985. In 1986, 24 applications were made between 6 January and 20 March. Salt was applied to "run-off" with a 20 litre capacity back-pack sprayer.

The first ("Fall") sample of twigs used for Na^+ and Cl^- analysis was collected on 28 December in 1984, and on 10 December in 1985, before any salt was applied to the experimental trees. The second ("Spring") sample was taken on 23 and 24 of April in 1985 and 1986 after all the salt had been applied and dormancy had been broken. Each sample consisted of a 5 to 8 cm long portion of twig. IR included the number of dead vegetative buds as well as measurement of twig dieback (cm). The IR were taken on 3 and 4 May in 1985 and 1986 and ratings were checked ten days later.

Twigs were prepared for Na^+ and Cl^- analysis by drying at 75°C for 48 h, and grinding through a 1 mm aperture sieve on a Wiley cutting mill. Analysis was performed on 0.5 g of dry, ground twig, samples were shaken for 30 minutes in 25 ml of 5% nitric acid (Hofstra and Hall 1971). Ten ml of

this solution was filtered through Whatman No. 1 filter paper. Sodium ion concentration was measured using a AA-4 Techtron atomic emission spectrophotometer. The remaining 15 ml of solution was incubated at 21°C for 2.5 h after addition of 0.3 ml of ionic strength adjuster (5 M $NaNO_3$). Chloride ion concentration was determined by using an Orion chloride ion (solid state) electrode (No. 9417B, Fisher Scientific, Toronto).

The amount of Cl^- and Na^+ that had accumulated in twigs was determined by subtracting the "Fall" (i.e., initial) concentration of these ions from the "Spring" (i.e., final) concentration. In 1985 and 1986, all the Cl^- and Na^+ data were normally distributed, necessitating no transformation. The bud IR data from both years was transformed using arcsin $\sqrt{x}$, where x = dead buds/total buds. This transformation was used because of the binomial nature of the data; however, a weighted analysis was necessary since the denominators (total buds) were unequal (Steel and Torrie 1980). The log (x + 1) transformation was used to stabilize the variance of twig dieback means when needed. All transformations were checked using analysis of the residuals and the data were found to have a normal distribution indicating that the transformations were successful in stabilizing the variances. Two-way analysis of variance (ANOVA) was used to determine if treatment significantly affected levels of Cl^- and Na^+ concentration, bud injury and twig dieback. In 1985, covariant analysis was included in IR to determine if twig diameter affected the levels of IR. Treatments with significant effects were identified using the least square means (LSM) method (Snedecor and Cochran 1967).

2.1.1.2/ Potted trees - One-hundred and forty potted, three-year-old Malling-26 apple rootstocks were used for testing in 1985-1986. Pots were located at the Horticultural Research Station, Vineland. Each pot contained one tree and represented an experimental unit. The experiment was replicated ten times and each replicate consisted of 14 pots (i.e., 6 protectants + control x 2 applications). Experimental design was RCBD and analysis was with ANOVA and LSM. Sampling of plant tissues, application of salt, and analysis of Cl^- and Na^+ ion levels was as described in section 2.1.1.

2.1.2/ White Pine - During the 1984-1985 winter, ten mature white pine trees located in a woodlot 60-80 m away from the Queen Elizabeth Way (Q.E.W.) were used for testing while in 1985-1986, three-year-old potted white pines were used. The experimental design and application of the protectants were the same as previously described for apple. However, in 1984-1985, protectants 1 to 18 (Appendix 1) were tested in white pine (excluding Nos. 2, 4 and 8) while in 1985-1986, protectants 1 to 8 were tested (excluding 5 and 7). Samples collected on 28 December 1984, 8 March 1985, 17 December 1985 and on 26 March 1986 consisted of approximately 1 g (dry weight) of needles taken from the terminal point of a shoot. IRs taken from these needles were rated as described by Hofstra and Hall (1971). They were processed as per apple for Na^+ and Cl^- determinations. There was no need to transform the data obtained. Data were analyzed using ANOVA and LSM.

2.2/ Results and Discussion

2.2.1/ Apple

2.2.1.1/ Experimental plot - Initial analysis of the data from 1984-1985 and 1985-1986 revealed that application time did not significantly affect Na^+ and Cl^- concentrations in twigs. Percent dead buds or twig dieback were not affected by application time. Thus, application time was removed from the model in both years.

During the winter of 1984-1985, none of the 18 protectants applied to Golden Delicious apple branches significantly affected Na^+ and Cl^- concentrations in the twigs (Table 1). However, protectant application significantly affected Cl^- levels in the twigs of Empire apple trees (Table 2). Further analysis with the least significant means (LSM) test revealed that none of the protectants affected Na^+ or Cl^- levels in the twigs of Golden Delicious but protectants 4 (RD 1725) and 8 (RD 1724) (Appendix 1) were associated with significantly lower Cl^- levels and protectant 4 with significantly lower Na^+ levels in Empire twigs (Table 2). The application of protectants significantly affected the percentage dead buds in Golden Delicious and Empire. Golden Delicious trees to which protectants 2, 3, 4, 5, 7, 10 and 12 (Appendix 1) had been applied had a significantly lower percentage of dead buds than those trees to which the other 11 protectants had been applied (Table 1). Protectants 2, 4, 8 significantly reduced the percentage of dead buds on branches of Empire trees (Table 2). The application of protectants also significantly affected dieback in both Golden Delicious and Empire trees. The application of protectants 2, 3, 4, 5, 7 and 8 significantly reduced dieback in the Golden Delicious (Table 1) whereas only protectants 4 and 5 reduced dieback in the Empire (Table 2).

During the winter of 1984-1985, the application of protectants significantly affected Cl^- and Na^+ levels in the twigs of Golden Delicious (Field) and Na^+ levels in the twigs of Empire apple trees. None of the protectants applied to Golden Delicious branches was associated with a significantly lower concentration of Cl^- and Na^+ (Table 3). Moreover, protectants 5 and 6 were associated with significantly higher Cl^- and Na^+ levels in Golden Delicious (field) twigs (Table 3). In Empire, protectant 4 affected the levels of Cl^- ions while protectants 2 and 4 were associated with a significantly lower concentration of Na^+ (Table 3). However, protectant 5 had a significantly higher level of Na^+ in Empire (Table 3).

Results from the two winters were consistent in showing higher levels of Na^+ and Cl^- ions, higher percent dead buds and dieback in Empire than in Golden Delicious (Tables 1, 2, 3). Empire appeared to be more susceptible to salt-spray than Golden Delicious. The shoots of Empire had more pubescence than Golden Delicious and twigs were also, in general, much thicker in diameter. This suggests that the pubescence in Empire does not permit complete coverage of the shoot with the protectants, resulting in increased Cl^- Na^+ and IR. However, the control, which had no protectant, also had higher levels of Cl^-, Na^+ and IR in Empire than Golden Delicious. The application of the protectants during the two winters did not result in any phytotoxic effects in either Golden Delicious or Empire apple trees.

2.2.1.2/ Potted trees - During the winter of 1985-1986, the protectants applied to the rootstock M-26 significantly affected Cl^- and Na^+ concentrations in the twigs, percent dead buds and twig dieback. Further analysis with the LSM revealed that twigs with protectants 2, 3, 5, and 8 (Appendix 1) had a significantly higher level of Cl^- than those twigs without protectants (Table 3). Similarly, twigs

with protectants 1, 2, 5 and 8 had a significantly higher level of Na^+ than those twigs without protectant (Table 3). All of the eight protectants sprayed on twigs of M-26 in 1985-1986 had a significantly lower percent dead buds than those twigs without protectant (Table 3). Protectants 1, 2, 3, 4, 5, and 7 had significantly lower level of dieback than twigs without protectant. It is not clear why the percent dead buds and dieback were, in general, lower than the control when levels of Cl^- and Na^+ ions were higher with the protectants than without them.

The twigs in M-26 were thin and small. This may explain the high levels of Cl^- and Na^+. However, it does not explain the reduced IR in those twigs with protectants. Factors, such as age of the trees, exposure to wind and temperature may have affected the damage intensity on M-26 trees.

2.2.2/ White Pine

2.2.2.1/ Woodlot - During the winter of 1984-1985 (Table 4), there was a greater accumulation of salt from the QEW than expected. The white pines used in these tests received salt-spray contamination from the QEW resulting in extensive damage on all the samples. Nevertheless, the application of protectants significantly affected the level of Cl^- and Na^- ions and IR. Protectants 1, 3, 6, 7, 9, 16 and 18 significantly lower the levels of Cl^- ions in their needles while protectants 1, 3, 6, 12 and 16 significantly reduced the levels of Na^+ ions (Table 5). Injury ratings were lower in needles sprayed with protectants 1, 3, 6, 7, 9, 11, 12 and 16 (Table 5). There were no phytotoxic effects of any of the protectants tested on the white pine needles.

These results were encouraging, considering the contamination of Cl^- and Na^+ from the highways. Protectants such as 1, 3, 6 and 9 were visible on the needles in the spring. Some

appeared white, while others left a shiny surface on the needles.

2.2.2.2/ Potted trees - The salt applied to the potted pines resulted in extensive damage. The level of Cl^- and Na^+ was significantly affected by the protectants tested. Analysis with LSM indicated that needles sprayed with protectants 3, 5 and 8 had significantly higher levels of Cl^- and Na^+ than those with other protectants or control (Table 6). The concentrations of Cl^- and Na^+ were extremely high when compared to the concentrations at the woodlot plot (Table 5). These levels resulted in sudden browning of most of the needles in all white pine. Soil salts were measured for these pots and found to be within a normal range. Therefore, it was assumed that all the damage observed was due to salt-spray damage. Clearly, under such high salt concentrations, none of the protectants was effective in preventing salt-spray damage.

Young trees are more susceptible to salt-spray injury than mature trees. This would explain why the same applications of 2% salt in the potted white pine and apple trees resulted in different intensity of damage. The levels of Cl^- and Na^+ in the tissues of white pine were excessively high and three to four times higher than in any of the apples.

3/ HIGHWAY SITES

3.1/ Materials and Methods

Six deciduous (apple, peach, elm, lilac, willow and maple) and three coniferous (Austrian, red and white pine) tree species (Appendix 3) were selected on six sites along three four-lane highways in Ontario.

3.1.1/ Apple - Ten apple trees, Golden Delicious, located in a commercial orchard along the south side of the Queen Elizabeth Way (QEW) near Grimsby, were used in 1985-1986 and 1986-1987. The trees were in a row parallel to and 10 m from the highway.

The RCBD experimental design was used with each tree being a block and each block replicated eight times. Branches with several shoots were sprayed with eight protectants in 1985-1986 and five in 1986-1987 (Appendix 1). All experimental methods and materials were as described in section 2.1.1 with the exception that salt applications were not artificial and depended on the deicing salt applied to the highway. In 1986-1987, the five protectants, Joncryl 1938 (1), RD 1726 (2), Folicote (3), RD 1725 (4) and Siliconate 51T (5), were applied with a 20 litre capacity back-pack sprayer on 6 November. "Fall" sampling was performed on 10 December 1985 and 12 November 1986 while "Spring" sampling was on 24 April 1986 and 16 April 1987.

3.1.2/ Other Deciduous Species

Five other deciduous species were tested in 1986-1987. Eight peach trees located at the QEW site described in section 3.1.1 were used in 1986-1987. Elm and lilac were located at highway 400 northbound, north of Toronto at km 44 and 54 respectively. Eight elm trees, 30 m away from the highway, and eight lilac bushes, 25 m away from the highway were tested. Silver maple and black willow were located

50 m from the road on Hwy 401 eastbound one km west of James Snow Parkway. Trees selected had evidence of previous salt injury and dead twigs were removed before protectants were applied.

Experimental design and methods for all species were as described in sections 3.1.1 and 2.1.1.

3.1.3/ White Pine and other Conifer Species
White, Austrian and red pine were tested in 1986-1987. White and red pine were located on Hwy 401 eastbound, one km west of Guelph Line, west of Milton. Eight red pines were parallel and 45 m from the highway and eight white pines ranged between 40-45 m from the highway. The eight Austrian pines were on Hwy 400 northbound and at km 52 north of Toronto. The trees were located at uneven distances from the highway and ranged between 15-20 m. All other experimental design and methods were as described in sections 2.2.2.

3.2/ Results and Discussion

3.2.1/ Apple - During the winter of 1985-1986, the protectants applied to Golden Delicious (QEW) significantly affected the Cl^- levels in the twigs. Further analysis with LSM indicated that protectants 1, 2, 3, 4, 5, 6 and 8 (Appendix 1) were associated with significantly lower levels on Cl^- in the twigs (Table 3). The percentage dead buds was significantly affected by the application of protectants to Golden Delicious (QEW). Branches to which protectants 1, 2, 3, 4, 5, 7 and 8 had been applied had a significantly lower percentage of dead buds than those branches without protectant or with protectant 6 (Table 3).

During the winter of 1986-1987, none of the protectants applied to Golden Delicious apple twigs significantly affected Cl^- and Na^+ levels in the twigs (Table 7).

Analysis with LSM revealed that protectants 1, 2 and 4 had lower Na^+ levels in the twigs while protectant 1 was associated with lower levels of Cl^- in the same twigs (Table 7). The application of protectants affected the percentage of dead buds in apple twigs. Twigs sprayed with protectants 1, 2 and 5 had a significantly lower percentage dead buds than those twigs with the other protectants or without any protectant (Table 7). The amount of dieback was affected by the application of protectants. Trees to which protectants 1, 2 and 5 had been applied had significantly lower amounts of twig dieback than those without protectant (Table 7).

During the 1986-1987 winter, the application of deicing salt was reduced on the QEW compared to other years. Thus it was not a good year to study salt-spray injury at the QEW site because little damage was observed in all plots.

3.2.2/ Other deciduous species - During the winter of 1986-1987, none of the protectants applied to peach, elm, maple, lilac and willow branches significantly affected Na^+ concentrations or percentage of dead buds. However, protectant applications significantly affected the levels of Cl^- in peach, elm and maple. Further analysis with LSM indicated that protectant 1 had a significantly lower level of Cl^- than any of the other treatments in peach (Table 7). However, the same protectant had a higher test level of Cl^- ion than the other treatments in elm. Analysis did not show any differences between Cl^- levels in maple, lilac or willow (Table 7). The amount of dieback was significantly affected by the application of protectants in elm , maple and lilac. Protectants 1, 2 and 5 were associated with lower incidence of twig dieback in elm, protectant 4 in maple and protectants 1, 3, 4 and 5 in lilac (Table 7). The twigs in willow were less than 3 mm in diameter, thus more susceptible to damage than a thicker twig, such as peach or

maple. In willow, there was a total bud kill and dieback regardless of treatment (Table 7).

In general, results with the deciduous species were variable and inconclusive. This variability in response to the protectants may be due to a small sample size. If the film on one twig out of ten cracks, and damage occurs, that constitutes a large percentage when compared to one needle out of several hundred. If damage occurs on one needle, it does not affect the results with the same intensity that one twig does.

3.2.3/ White Pine and other Conifers - The protectants applied to white pine needles significantly affected the level of Cl^- and Na^+ in the needles. Similarly, protectants applied to red pine needles significantly affected the level of Cl^- and Na^+ in the needles. All protectants were associated with lower levels of Cl^- in white and red pine (Table 8). Similarly, all needles sprayed with the protectants had lower levels of Na^+ in red pine and all but protectant 2 in white pine (Table 8). Injury rating was significantly affected by the protectants in white and Austrian pine. All protectants, except 1 in white pine and 2 in red pine, had significantly lower IR than those needles not sprayed with a protectant (Table 8).

These results indicate the potential for using protectants for preventing salt-spray injury on pines with different levels of tolerance to salt.

4/ SCANNING ELECTRON MICROSCOPY (SEM)

4.1/ Introduction

Apple trees planted along highways have been injured by deicing salts and salt-spray injury symptoms have been observed when salt has been applied artificially (Hofstra and Lumis 1975, Hofstra et al. 1979). The use of antidesiccants (protectants) for the prevention of salt-spray injury has been under study. One major problem in assessing the protectants is that they are translucent when applied, and not visible when using hystological techniques. Other investigators have used scanning electron microscopy (SEM) to study the effects of antitranspirants (Davies and Kozlowski 1974, Pair and Still 1982) and salt-spray injury (Barrick et al. 1979 and Krause 1982) on different species of trees. SEM was used to study the integrity of the film formed by the protectants when sprayed and to observe the effect of road-salt and -sand on those films.

4.2/ Materials and Methods

Branches of apple, Golden Delicious, were tagged and sprayed with five protectants (Appendix 2, #1-5) in November 1986. One branch, which served as a control, was tagged but not sprayed with protectant (NWS). These branches were located adjacent to the QEW in the Niagara Peninsula and were exposed to salt spray from the highway. One additional branch was tagged at the Horticultural Research Station, Vineland, close to Lake Ontario, and was not exposed to salt spray (NOS).

The first sample of one 20-cm shoot from each treatment was examined on 12 November 1986, before any salt was applied to the QEW. Thereafter, four 8-10 mm twig samples were taken from each shoot on 11 December 1986, 15 January, 5 February,

26 February, 19 March, 9 April and 23 April 1987. They were mounted with double-stick tape on stubs, air dried for 72 hours, coated (about 20-30 nm) with gold-palladium and observed with a Hitachi S-570 SEM and 25 mm working distance at 20 kv. Magnifications ranged from 100x to 2500x. Selected samples were analyzed further using a Jeol JXA-50A electron probe microanalyzer and energy dispersive x-ray spectrums were obtained from these samples.

4.3/ Results and Discussion

Scanning electron micrographs revealed that all protectants evenly covered the twig in all areas except the lenticels (Fig. 1A-1E, 2A, 2B). Protectants 2 and 4 (Fig. 1B, 1C) covered the lenticels almost completely while protectants 1, 3 and 5 only partially (Fig. 1A, 1C, 2A). By comparison, the twigs without protectant, either UWS or NOS had lenticels exposed (Fig. 2B, 2C). SEM micrographs showed that by February or March most of the lenticels were exposed in all treatments and in UWS and NOS samples (Fig. 1E-1H, 2E-2G).

The protectants remained intact over most of the sampling period. However, protectant five (Fig. 20) developed longitudinal cracks in one sample by 11 December 1986, in another by 5 February and in the remaining samples thereafter. When the protectant film cracked the twig epidermis also cracked and the cortex tissues were exposed. One sample to which protectant three had been applied (Fig. 2H) also appeared with many longitudinal cracks on 11 December 1986. However, no other cracks were visible until 9 April 1987 with this protectant. Cracks, which also appeared on the UWS, were not only longitudinal but also across the width of the twigs (Fig. 3A). UWS sampled on 26 February 1987 had all the cortex tissues exposed (Fig. 3B) and subsequent UWS samples had extensive cracks (Fig. 3A

Cracks in NOS samples did appear until 9 April 1987 (Fig. 3C). Prior to that, all surfaces appeared smooth with clear ridges on the surface (Fig. 3D). Many twigs were covered with hairs (Fig 1D, 1G, 1H and 3E) but coverage of the surface did not appear affected by them (Fig. 3E). The twigs were completely covered by the protectants and appeared smooth from 12 November 1986 to 5 February 1987.

Crystals of different appearances were found in all samples (Fig. 3E-3H). Protectants 1, 2 and 3 appeared to have greater accumulations of crystals (i.e., Fig. 3G and 3H) in samples collected on 11 December, 15 January and 5 February 1987. Later samples showed the presence of crystals associated with all protectants and in similar amounts.

Energy dispersive x-ray spectrums revealed the composition of these crystals to be of silica, calcite and calcium carbonate. For example, the composition of the crystal in Fig. 4A indicates the presence of Ca, Si, Mg, Na and Fe (fig. 4B). The gold (Au) in the spectrum is a result of the coating with gold palladium. Sodium chloride crystals were present in small numbers and had a typical rectangular shape (Fig. 5A). A typical NaCl spectrum has Na, Cl and the Au from the coating (Fig. 5B). SEM micrographs also revealed that some samples had specks and/or crystals with halos around them (Fig. 6A), and energy dispersive x-ray analysis indicated that the specks and halos were an artifact resulting from coating for the SEM. In fact, all specks were gold (Fig. 6B) and the crystals inside the halos had similar composition to other silica and calcite crystals (Fig. 6C).

5/ GENERAL CONCLUSIONS AND RECOMMENDATIONS

Initial testing during the winter of 1984-1985 of a wide range of chemicals on two apple cultivars (Empire and Golden Delicious) and white pine, resulted in the selection of some protectants for further evaluation. Folicote (#3) and Rhoplex (#6) performed uniformly and provided better protection than the other protectants tested in both apple and white pine. Wilt-pruf (#7) and Rhodorsil (#5) were effective on apple, while Joncryl 1938 (#1), Gelva (#16) and Hercobind TK (#12) were effective on white pine. RD 1724 (#18), RD 1725 (#4) and RD 1726 (#2) were tested only on apple and were found to be very effective. Gelva and Hercobind were difficult to apply and plugged spraying nozzles. None of the products were phytotoxic to apple or to white pine.

Further screening of eight protectants during the winter of 1985-1986 revealed that they were effective at moderate salt levels (Golden Delicious - QEW) and variable in performance when levels of salt were high (Golden Delicious - field). Moreover, twigs of Malling-26 (M-26) rootstock twigs sprayed with protectants had greater levels of Cl^- and Na^+ than those without protectant (Table 3). It is not clear why Cl^- and Na^+ accumulation were so high in M-26 unless this was related to the size and thinness of the twigs. All the M-26 twigs were very thin making them more susceptible to salt-spray injury. In white pine, the injury was very extensive due to very high Cl^- and Na^+ accumulations; none of the protectants prevented injury.

Despite the variability of the results in 1985-1986, five protectants were selected for further testing: Joncryl 1938 (#1), RD 1726 (#2), Folicote (#3), RD 1725 (#4), and Rhodorsil (#5). Protectant RD 1724 had performed similarly but two other products from International Waxes were selected.

During the winter of 1986-1987, six deciduous tree species tested along the QEW, Hwy 400 and Hwy 401 exhibited a variable response to the protectants. However, protectants 1, 2, 4 and 5 significantly reduced the levels of Cl^- and Na^+ and injury rating in Golden Delicious trees. The protectants tested had little effect on Cl^- and Na^+ or the IR in peach, elm, maple, lilac and willow. It is not clear if this is the typical response for these species or a specific response to the precipitation and temperature distribution during the 1986-1987 winter (Table 4). One year of data is not sufficient to finalize conclusions.

In 1986-1987, results with the three coniferous species were encouraging. In particular, results with white pine and red pine indicated that all protectants prevented Cl^- and Na^+ accumulation in the tissue and reduced IR. In Austrian pine all protectants reduced IR but only protectants two and four significantly reduced the levels of Cl^- and Na^+ ions. Results with apple indicated some reduction in levels of Cl^- and Na^+ and in IR. On the other hand, results with the other deciduous species were variable and reduction in IR was not clear.

SEM indicated that the integrity of the different films is stable until February. None of the protectants had cracks in the film until 5 February with the exception of number 5. Cracks accumulated crystals of different kinds. When temperatures increase on a hot, sunny winter day, Cl^- and Na^+ can be absorbed by the tissue, resulting in injury. However, SEM also revealed that many of the crystals found on the surfaces of the twigs are not sodium chloride but silica, calcium carbonate and other particles.

In general, one year of field data is not sufficient to determine typical responses of the different protectants with all the species tested. It is important to repeat all

the highway experiments from 1986-1987 in order to have at least two years of field data. Similarly, results with the SEM could be expanded to white pine and analyzed further with one more year of testing.

It is recommended that the study be extended for at least one year to examine the following:

- The efficacy of the five selected protectants on the nine species studied along the highway with an increase in number of samples.
- Differences in response to the five protectants between deciduous species and evergreen species.
- Compare longevity of the film of deciduous and evergreen species using SEM.
- Analyze the crystals and particles found on twig and needle samples using the SEM.

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Table 1/ Effect of protectants on Cl^- and Na^+ ion concentration, arcsin $\sqrt{\text{dead buds/total buds}}$ and dieback on apple cultivar Golden Delicious, 1984-1985.

PROTECTANT[a]	Cl^- X (ppm)	Na^+ X (ppm)	Dead Buds X (%)	Dieback (cm)
None	78	40	45	1.5
1	99	42	32	1.0
2	64	45	10**[b]	0.3*[b]
3	58	34	22**	0.4*
4	90	43	7**	0.2**
5	85	44	17**	0.4*
6	87	46	33	0.5
7	66	37	23**	0.2*
8	72	42	6	0.1**
9	89	52	48	1.5
10	107	46	29**	1.4
11	139	56	42	1.5
12	87	46	31*	0.5
13	83	47	34	1.6
14	92	48	48	1.2
15	88	46	47	0.5
16	82	48	42	2.0
17	113	51	45	1.0
18	96	53	50	1.6

a/ Each value is average from 10 shoots.
b/ Significantly different from control as determined by least square means; *($P<0.05$), **($P<0.01$).

Table 2/ Effect of protectants on Cl^- and Na^+ ion concentration, arcsin V dead buds/total buds and log(dieback + 1) on apple cultivar Empire, 1984-1985.

PROTECTANT[a]	Cl^- X (ppm)	Na^+ X (ppm)	Dead Buds X (%)	Dieback (cm)
None	222	69	49	1.9
1	184	68	42	1.3
2	137	72	21*	1.0
3	154	70	37	1.1
4	92**[b]	46*	10*	0.7*
5	143	53	34	0.8*
6	166	59	35	1.3
7	156	68	45	2.1
8	104**	54	22*	1.0
9	154	66	51	1.7
10	163	62	58	2.3
11	204	68	55	2.7
12	154	61	49	1.7
13	266	84	49	1.8
14	139	72	49	1.5
15	185	77	46	2.1
16	179	70	53	2.7
17	238	75	53	2.7
18	154	64	41	1.8

a/ each value is average from 10 shoots.
b/ significantly different from control as determined by least square means; * ($P \leq 0.05$), ** ($P \leq 0.01$).

Table 3/ Effect of protectants on Cl^- and Na^+ ion concentration, dead buds and dieback on three apple cultivars and one rootstock, 1985-1986.

PROTECTANT[a]	Cl^- X (ppm)	Na^+ X (ppm)	Dead Buds X (%)	Dieback X (cm)
	GOLDEN DELICIOUS (FIELD)			
None	142	59	30	2.5
1	150	58	27	2.3
2	189	68	35	1.5
3	160	70	32	1.4
4	134	56	29	4.1
5	216*[b]	79*	35	3.9
6	221*	76*	34	2.4
7	168	60	24	2.2
8	154	61	23	1.5
	GOLDEN DELICIOUS (QEW)			
None	170	55	38	2.6
1	105**	40	25**	1.4
2	104**	41	21**	0.9
3	91**	33**	19**	0.5*
4	104**	48	24*	0.8*
5	104**	36*	23**	0.9
6	113*	41	34	2.7
7	127	43	23**	1.0
8	92**	37*	18**	0.4*
	EMPIRE			
None	276	83	40	4.0
1	250	78	20	2.4*
2	234	69*	25	3.5
3	274	85	35	3.5
4	214*	68*	26	8.1
5	307	109**	40	6.2
6	295	91	38	7.0
7	249	85	48	7.3
8	244	88	35	4.8
	MALLING-26 (M-26)			
None	199	65	59	4.6
1	275	98**	36**	2.2**
2	304*	100**	41**	2.8*
3	324**	92	41**	2.5*
4	162	61	37**	1.9**
5	343**	109**	30**	2.0**
6	238	81	39**	2.8
7	241	80	41**	3.1*
8	339**	112**	38**	3.6

a/ Each value is average from 16 shoots except M-26 which is 20 shoots.

b/ Significantly different from control as determined by least square means; *($P<0.05$), **($P<0.01$).

Table 4/ Weather data for the Horticultural Experiment Station, Vineland Station, Ontario during the months of December, January, February and March.

Year	December	January	February	March
Average mean daily maximum temperature (°C)				
86-87	2.6	-0.1	0.2	6.1
85-86	-0.2	-0.2	-2.0	6.4
84-85	5.0	-2.8	-0.3	6.1
70 year mean	2.0	-0.5	0.0	4.3
Average mean daily minimum temperature (°C)				
86-86	-2.1	-5.7	-6.4	-1.8
85-86	-6.2	-6.7-	-7.0	-2.1
84-85	-2.0	-8.7	-7.1	-1.9
70 year mean	-4.4	-7.3	-7.1	-3.0
Average mean daily temperature (°C)				
86-87	0.3	-2.9	-3.1	2.2
85-86	-3.2	-3.4	-4.5	2.1
84-85	1.5	-5.8	-3.7	2.1
70 year maean	-1.2	-3.9	-3.6	0.1
Rainfall (mm)				
86-87	82.2	4.2	11.8	42.2
85-86	17.4	39.2	39.6	50.8
84-85	64.4	5.2	32.0	92.0
70 year mean	38.8	29.6	30.4	47.0
Snowfall (mm)				
86-87	14.0	43.6	5.2	38.2
85-86	29.2	20.6	48.2	10.4
84-85	29.4	30.8	41.8	26.4
70 year mean	25.1	29.8	27.8	18.6
Total precipitation (mm)				
86-87	96.2	47.8	17.0	80.4
85-86	46.6	59.8	87.8	61.2
84-85	93.8	36.0	73.8	118.4
70 year mean	63.9	59.4	58.2	65.6

Table 5/ Effect of protectants on Cl^- and Na^+ ion concentration and injury ratings (IR) in white pine, 1984-1985.

PROTECTANT[a]	Cl^- X (ppm)	Na^+ X (ppm)	IR (%)
None	438	116	33
1	245**[b]	62**	8**
2*	-	-	-
3	134**	53**	5**
4*	-	-	-
5	437	136	29
6	282**	77**	13**
7	262**	97	19*
8*	-	-	-
9	316*	104	17*
10	407	123	24
11	402	96	18*
12	338	81*	18*
13	425	122	24
14	360	103	16**
15	455	111	26
16	239**	78**	16**
17	539	159	38
18	279**	91	22

a/ Each value is average from 20 shoots.
b/ Significantly different from control as determined by least square means; *($P<0.05$), **($P<0.01$).

*Not applied to white pine.

Table 6/ Effect of protectants on Cl^- and Na^+ ion concentration and injury rating (IR) on white pine, 1985-1986.

PROTECTANT[a]	Cl^- X (ppm)	Na X (ppm)	IR (%)
None	959[b]	313	67
1	991	363	66
2	988	363	79
3	1015*	434**	77
4	1011**	404**	86*
5	-	-	-
6	963	309	65
7	-	-	-
8	1020**	442**	81

a/ each value is average from 16 shoots.
b/ analysis with the least square means resulted in no significant differences between control and treatments ($P \leq 0.05$).

Table 7/ Effect of protectants on Cl^- and Na^+ ion concentration, dead buds and dieback on six deciduous species planted along four-lane highways 1986-1987.

PROTECTANT[a]	Cl^- X (ppm)	Na^+ X (ppm)	Dead Buds % Vegetative	Flower	Dieback (cm)
		APPLE (GOLDEN DELICIOUS)			
None	164	73	28	-	1.3
1	102*[b]	52*	6**	-	0.4*
2	125	50*	9*	-	0.3**
3	128	54	19	-	1.0
4	124	52*	15	-	1.1
5	128	54	9*	-	0.4*
		PEACH			
None	178	73	42	34	3.6
1	115*	54	52	42	1.7
2	137	64	54	31	3.2
3	156	75	34	31	2.1
4	196	76	29	27	2.2
5	176	81	26	24	1.9
		ELM			
None	335	135	5	-	30
1	588*	189	3**	-	16*
2	330	145	4	-	14**
3	337	131	4	-	24
4	392	145	4	-	25
5	399	145	3*	-	11*
		MAPLE			
None	305	135	73	-	0.5
1	379	151	73	-	0.6
2	200	93	64	-	0.4
3	336	129	65	-	0.5
4	212	107	57	-	0.3*
5	325	127	62	-	0.5
		LILAC			
None	344	188	5	-	28
1	523	179	4	-	17*
2	456	158	5	-	23
3	469	148*	4	-	14**
4	288	159	3*	-	12**
5	404	164	3*	-	15*
		WILLOW			
None	503	249	100	-	30
1	545	219	100	-	30
2	585	217	100	-	30
3	542	212	100	-	30
4	515	205*	100	-	30
5	521	222	100	-	30

a/ Each value is average from 8 shoots except for maple which had 7.

b/ Significantly different from control as determined by least square means; *($P<0.05$), **($P<0.01$).

Table 8/ Effect of protectants on Cl^- and Na^+ ion concentration and injury rating (IR) on three evergreen species planted along four-lane highways 1986-1987.

PROTECTANT[a]	Cl^- X (ppm	Na^+ X (ppm)	IR X (%)
	WHITE PINE		
None	264	56	30
1	171**[b]	46	25
2	97**	29**	10**
3	126**	30**	8**
4	65**	30**	3**
5	143**	36**	19*
	RED PINE		
None	117	20	5
1	46**	8**	0**
2	38**	6**	3
3	21**	4**	1*
4	10**	2**	0**
5	43**	9**	0**
	AUSTRIAN PINE		
None	189	61	23
1	172	38	13**
2	97	20**	5**
3	165	41	9**
4	68*	19**	6**
5	145	33	9**

a/ Each value is average from 8 shoots.
b/ Significantly different from control as determined by least square means; *($P<0.05$), **($P\leq 0.01$).

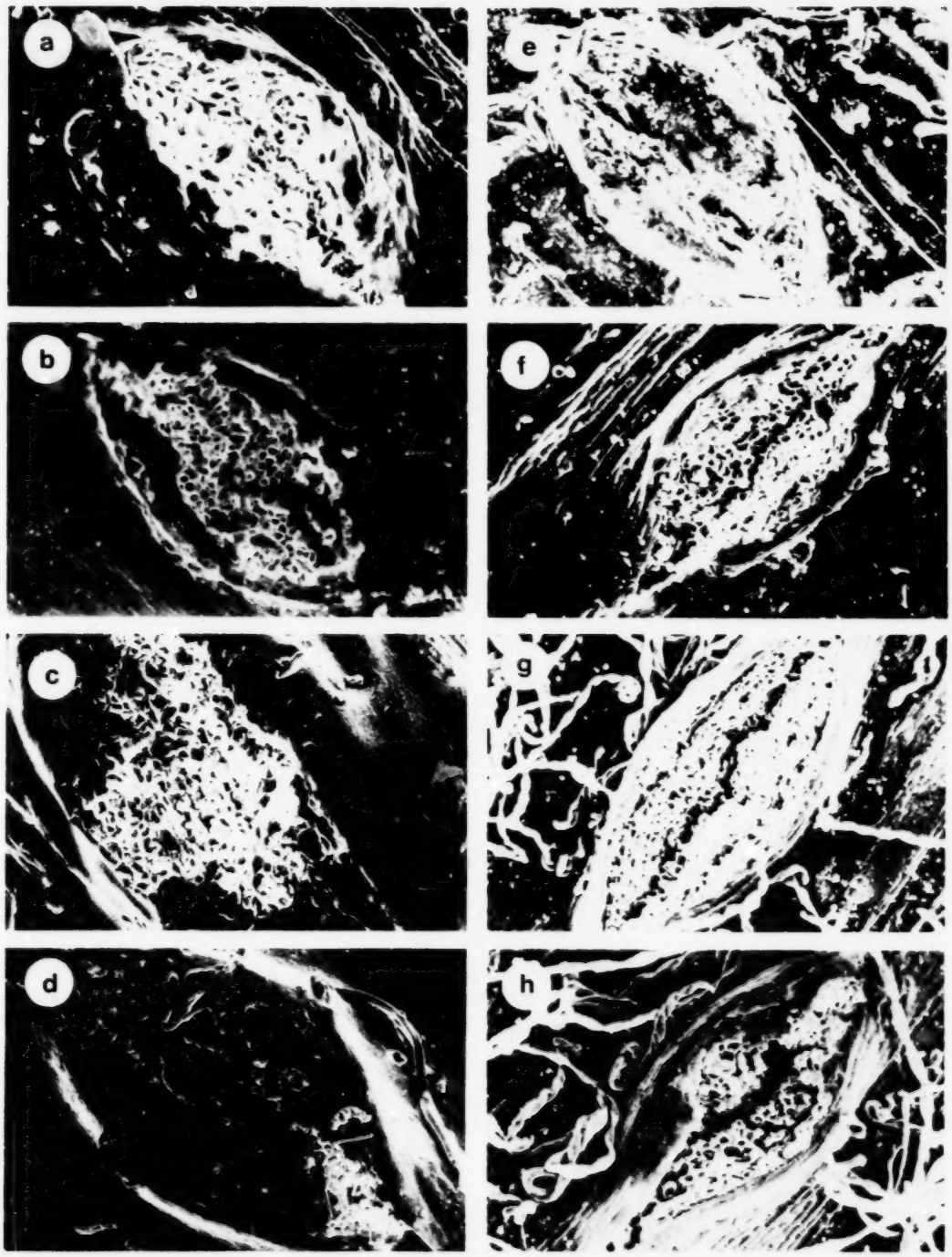


Fig. 1 Scanning electron micrographs of apple twig pores sprayed with different protectants and taken in December: a) Joncryl 1938 (700X), b) RD 1726 (300X), c) Folicote (500X), d) RD 1725 (400X); and in April: e) Joncryl 1938 (100X), f) RD 1726 (500X), g) Folicote (120X), and h) RD 1725 (170X).

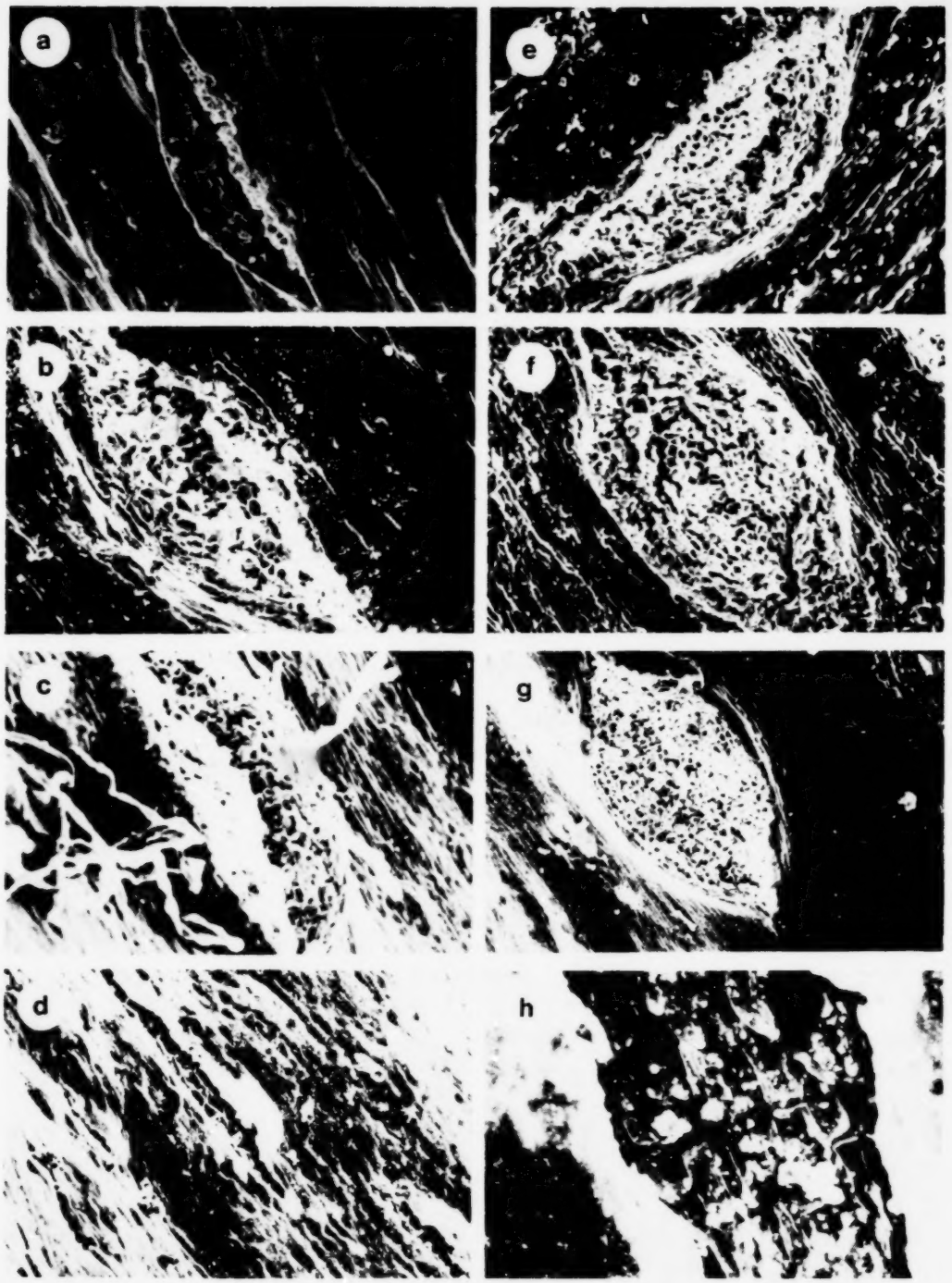


Fig. 2 Scanning electron micrographs of apple twig pores sampled in December and April respectively: a,e) sprayed with Rhodorsil (350X, 150X); b,f) no protectant and exposed to highway salt (500X, 150X); c,g) no protectant and not exposed to highway salt (350X, 100X); d) longitudinal crack on apple twig bank sprayed with Rhodorsil (200X); and h) crack on apple twig sprayed with Folicote (2500X).

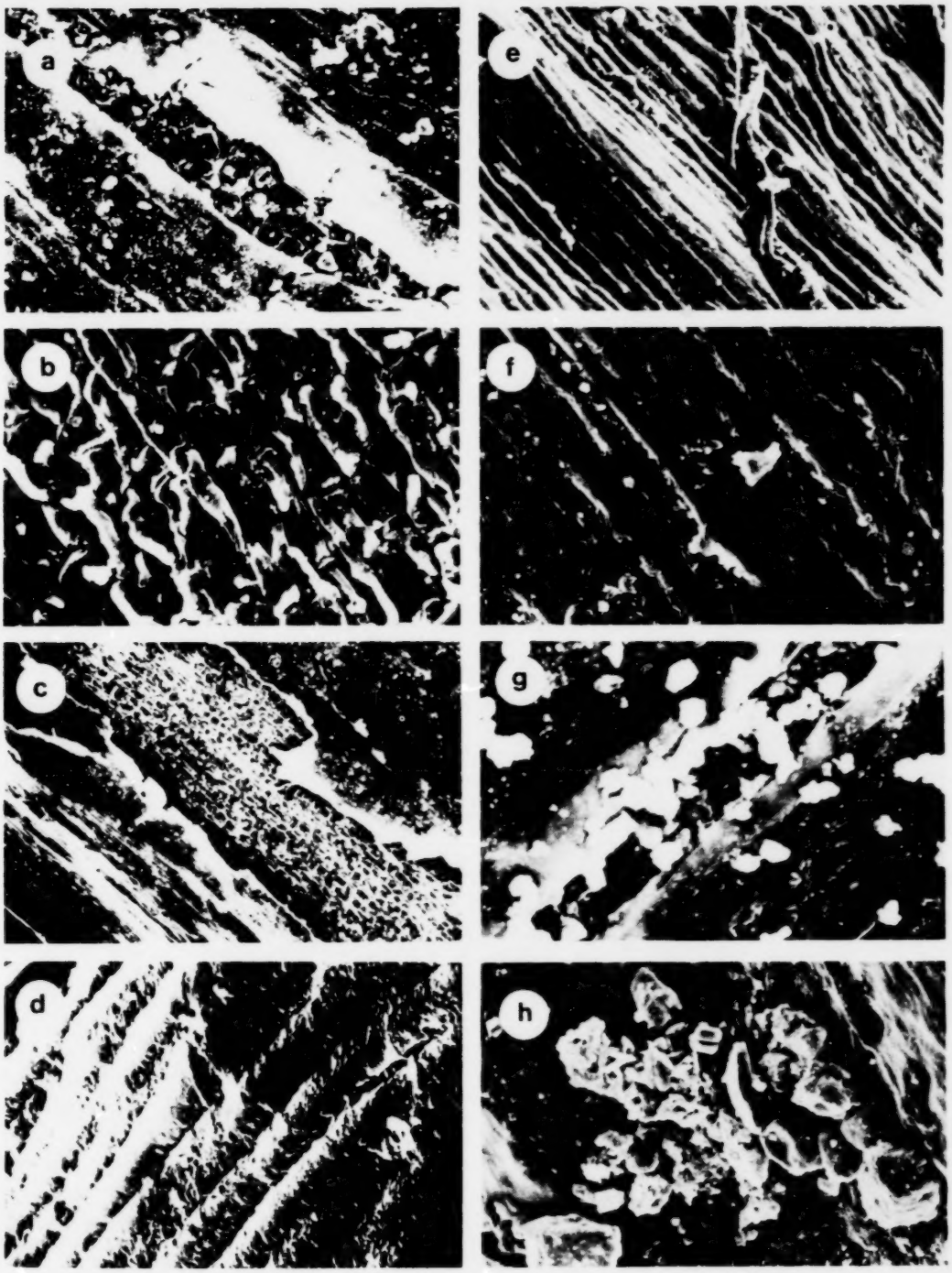


Fig. 3 Scanning electron micrographs of apple twigs and crystals on those twigs: a) longitudinal and crosswise crack on untreated twig with salt (UWS) (800X); b) UWS with all cortex exposed (600X); c) untreated-with-out-salt (VOS) sample with crack (250X); d) VOS surface of twig with distinct ridges (1000X); e) protectant two completely covering twig and hair (1000X); f) appearance of apple twig covered by protectant two and sampled in December (1500X); g) crystals inside crack on twig sprayed with protectant h) clump of crystals on surface of twig sprayed with protectant three (500X).

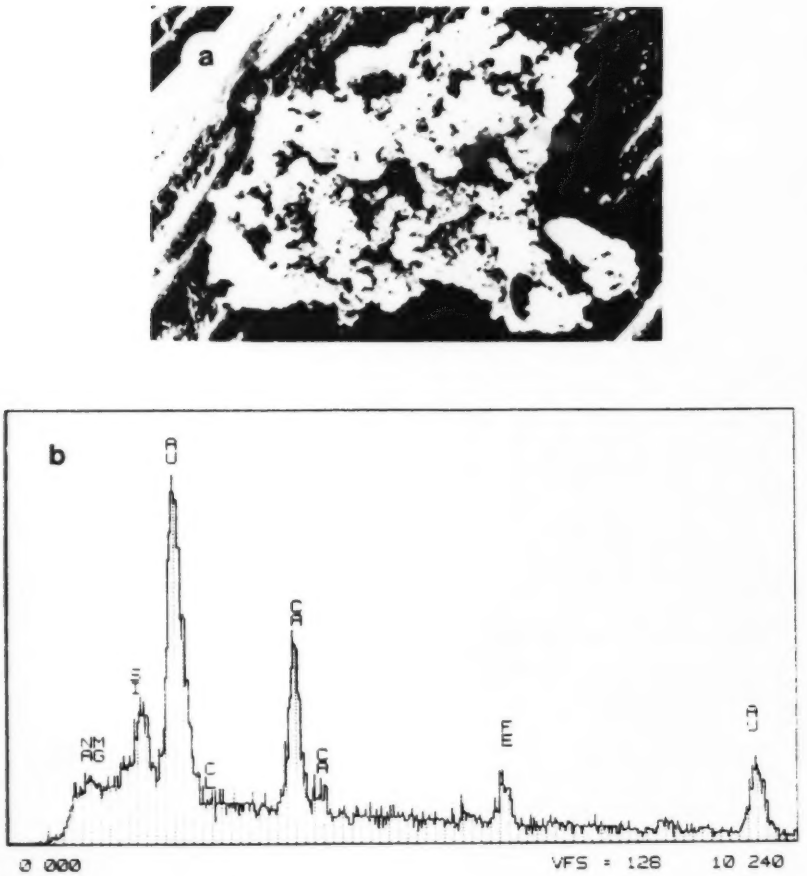


Fig. 4 a) Scanning electron micrograph of a clump of crystals found on apple twigs sprayed with protectant four (700X); b) energy dispersive x-ray spectrum corresponding of the crystal in a).

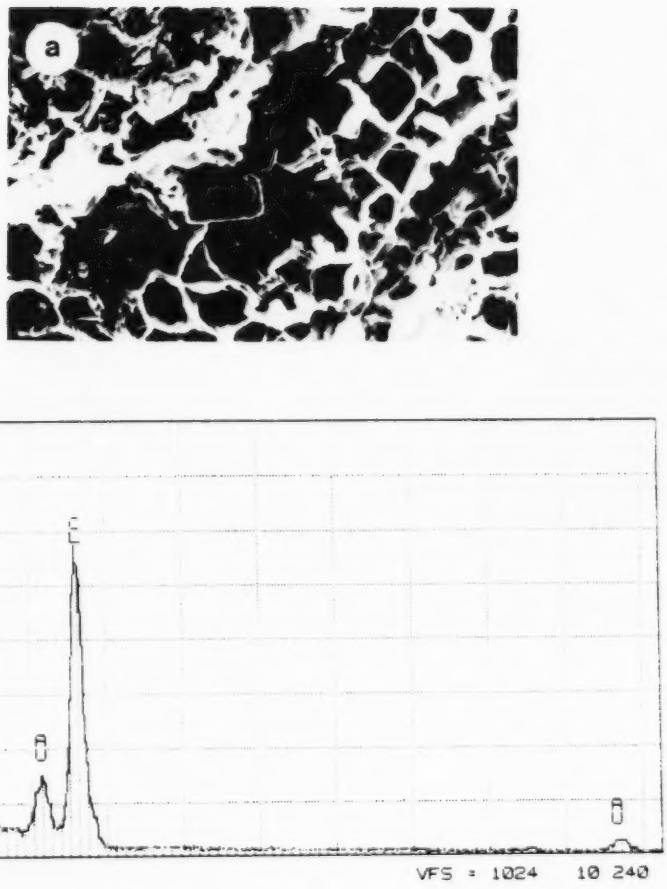
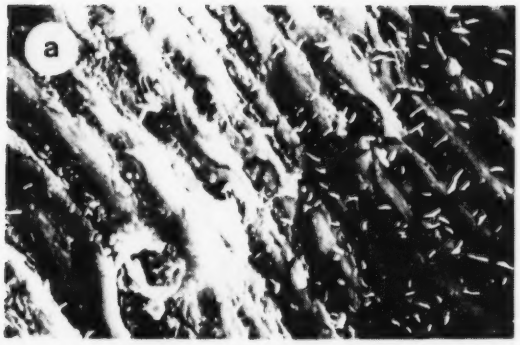
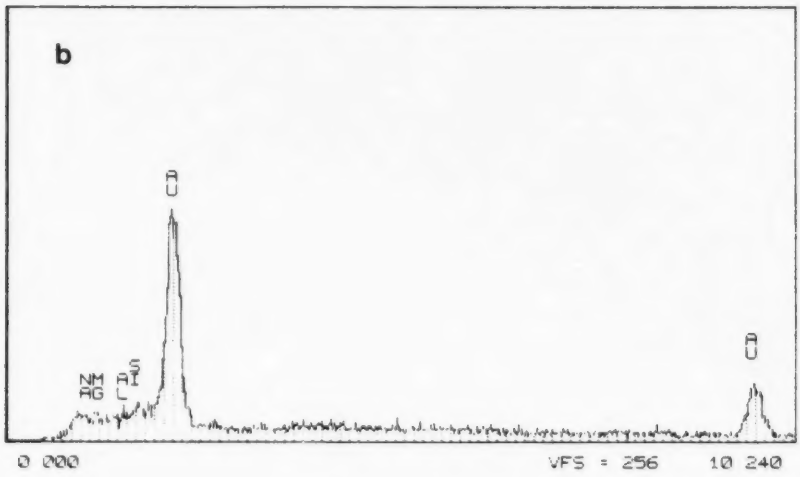


Fig. 5 a) Scanning electron micrograph of a pore on an apple twig containing a rectangular shaped sodium chloride crystal (1500X); b) energy dispersive x-ray spectrum of a sodium chloride crystal.





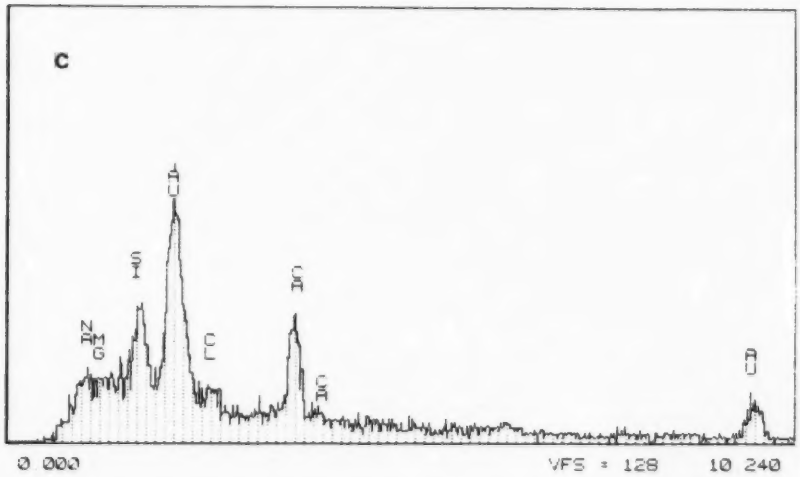


Fig. 6 (a) Scanning electron micrographs with halos and elongated "specks" (800X); b) energy dispersive x-ray spectrum of the elongated specks; and c) energy dispersive x-ray spectrum of a crystal inside a halo.

APPENDIX 1/ CHEMICAL PRODUCTS TESTED

No/	Name	Current uses	Type of Chemical	Company
1/**	Joncryl 1938	water-proof coating	acrylic polymer	S.C. Johnson & Son Ltd.
2/**	RD 1726	formulated for project	wax emulsion & additive	International Waxes
3/**	Folicote	Antidesiccant	wax emulsion	Aquatrols Corp.
4/**	RD 1725	formulated for project	wax emulsion	International Waxes
5/**	Rhodorsil (siliconate 51T)	treatment of tiles and brick	silicon	May & Baker
6/ *	Rhoplex AC-33	Antidesiccant adhesive	Acrylic polymer resin	Rohm and Haas
7/ *	Wilt-Pruf	Antidesiccant	pine oil emulsion	Wilt-Pruf Products
8/ *	RD 1724	formulated for project	wax emulsion	International Waxes
9/	Jon-cote 639	exterior protection	wax emulsion	S.C. Johnson & Son Ltd.
10/	Jon-cote 699	exterior protection	acrylic polymer	S.C. Johnson & Son Ltd.
11/	Jon-cote 614	surface protection	carnauba wax emulsion	S.C. Johnson & Son Ltd.
12/	Hercobind TK	Industrial-Research	resin emulsion - tall oil	Hercules
13/	Hercobind DS-C3	dust suppressant	resin emulsion - tall oil	Hercules
14/	Piccopale	adhesive, tackifier	hydrocarbon resin	Hercules
15/	APL Lustre	fruit wax	wax emulsion	Pennwalt
16/	Gelva TS 30	paints, coatings, adhesives, textiles	Polyvinyl Acetate resin	Monsanto
17/	Gelvatol 20/30	adhesives, binders	resin	
18/	Cloud Cover	Antidesiccant	Organic polymer emulsion	Adkar Inc.

NOTE: all products were tested in 1984-85.
* products tested in 1985-86.
** products tested in 1985-86 and 1986-87.

APPENDIX 2/ RATES AND CHARACTERISTICS OF PRODUCTS USED IN TESTS

No/	Name	Rate	% Solids in Solution	Low Temp. Threshold(°C)	Ease of Spraying*1	Colour when dried	Comments
1/	Joncryl 1938	1:5	8	4-5	1	translucent	
2/	RD 1726	1:3	10	4-5	1	translucent	
3/	Folicote	1:10	5	6-8	1	translucent	
4/	RD 1725	1:5	10	4-5	1	translucent	
5/	Siliconate 51T	1:50	10	0	1	translucent	
6/	Rhoplex AC-33	1:5	9.4	4-5	1	translucent	
7/	Wilt-Pruf	1:5		4-5	1	translucent	
8/	RD 1724	1:5	10	4-5	1	translucent	
9/	Jon-Cote 639	1:0	24	4-5	1	translucent	
10/	Jon-Cote 699	1:0	22	4-5	2	translucent	
11/	Jon-Cote 614	1:1	10	4-5	1	translucent	needles stick together
12/	Hercobind TK	1:5		4-5	3	brownish	strong odour
13/	Hercobind DS-C3	1:5		4-5	1	translucent	needles stick together strong odour
14/	Piccopale	1:5	11	4-5	1	white	
15/	APL Lustre	1:5		0	1	translucent	
16/	Gelva TS 30	1:5	11	0	3	white	
17/	Gelvatol 20/30	35%	12	0	1	translucent	
18/	Cloud Cover	1:5	7.2	6-8	2	translucent	

1 - Ease of spraying (1 = no problems; 2 = some difficulties; and 3 = serious problems).

APPENDIX 3/ COMMON AND SCIENTIFIC NAMES OF SPECIES TESTED AND THE RATING FOR RESISTANCE TO SALT-SPRAY INJURY.

	Rating
Apple *Malus pumila*	4[a]
Peach *Prunus persica*	4
White elm *Ulmus americana*	3
Black willow *Salix nigra*	3
Silver maple *Acer saccharinum*	3
Common lilac *Syringa vulgaris*	2
White pine *Pinus strobus*	5
Red pine *Pinus resinosa*	4
Austrian pine *Pinus nigra*	1

[a] - 1 indicates no twig dieback or needle browning of conifers and no dieback, tufting, or inhibition of flowering of deciduous trees and shrubs. 5 represents complete branch dieback and needle browning of conifers, and complete dieback, evidence of previous tufting, and lack of flowering of deciduous trees and shrubs. Ratings 2, 3 and 4 encompass slight, moderate and extensive injury symptoms (Lumis et al. 1983).